Vol. 40 (2009) *ACTA PHYSICA POLONICA B* No 3

POPULATION OF NEUTRON-RICH NUCLEI AROUND ^{48}Ca WITH DEEP INELASTIC COLLISIONS*

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(Received November 20, 2008)

The deep inelastic reaction ^{48}Ca+^{64}Ni at 6 MeV/A has been studied using the CLARA–PRISMA setup. Angular distributions for pure elastic scattering and total cross-sections of the most relevant transfer channels have been measured. The experimental results are compared with predictions from a semiclassical model, showing good agreement for the presently analyzed few neutrons transfer channels. The γ-decay of the most intense reaction products has also been studied, giving indications of the population of states with very short lifetimes.

PACS numbers: 21.10.Re, 21.10.Gv, 25.85.Ge, 27.90.+b

* Presented at the Zakopane Conference on Nuclear Physics, September 1–7, 2008, Zakopane, Poland.

1. Introduction

One of the most investigated issues in nuclear physics is the influence of the N/Z ratio on the structure of the nucleus. Various models predict relatively well properties for nuclei close to the valley of stability, while disagreement is found for more exotic systems. For this reason the fundamental modes of excitation, vibrations and rotations, are studied as a function of N/Z. In a recent experiment we investigated the population and decay of neutron-rich nuclei around ^{48}Ca by means of deep-inelastic collisions (DIC) at energies ≈ 2.5 times above the Coulomb barrier. Neutron-rich Ca isotopes are particularly interesting since highly excited states of E1 character have been measured in photon scattering experiments [1], being interpreted as pygmy dipole resonance states. We present here the results of a preliminary analysis of the angular distributions for pure elastic scattering and total cross-sections of the most relevant transfer channels. The data are compared with the semiclassical multi-nucleon transfer model of Ref. [2]. In addition, a preliminary analysis of the γ-spectra is shown.

2. Experimental setup and data analysis

The experiment was performed at Laboratori Nazionali di Legnaro, using a ^{48}Ca beam provided by the Tandem-Alpi accelerators at 270 MeV, impinging onto a 0.98 mg/cm^2 thick ^{64}Ni target. The reaction products were detected by the magnetic spectrometer PRISMA and their γ-decay was measured in coincidence by the CLARA Ge array [3]. PRISMA was placed at 20°, which is the grazing angle for this reaction. Several atomic species have been populated, from $-4p$ to $+4p$, and mass spectra corresponding to the pick-up and stripping of several neutrons have been obtained.

From a preliminary analysis of the data, angular distributions for pure elastic scattering and total cross-sections for the most relevant transfer channels have been obtained. The elastic scattering cross-section of ^{48}Ca has been evaluated following the procedure described in Ref. [4] and is illustrated in Fig. 1(a). The intensity of the pure elastic scattering has been determined by subtracting from the total kinetic energy loss (TKEL) spectrum of ^{48}Ca, measured in PRISMA (dashed line), a similar event distribution obtained requiring a γ-coincidence with the CLARA array (solid line), normalized in the tail region. The resulting peak (shaded area) is centered around TKEL ≈ 0 with a FWHM ≈ 2.5 MeV, which is consistent with the combined energy resolution of the ^{48}Ca beam and of the experimental setup, as also reported in Ref. [4]. By doing the subtraction in steps of 1 degree over the angular acceptance of PRISMA ($+14° < \theta < +26°$), the elastic scattering distribution of ^{48}Ca has been obtained, its ratio to the Rutherford cross-section compared to the calculation by the GRAZING code (solid line) [2] is shown in the inset of Fig. 1(a). This ratio allows to obtain a normalization factor which is used to estimate the total cross-sections (*i.e.* integrated in Q-values and solid angle) for some of the most intense reaction products, assuming a bell shape angular distribution mostly covered by the acceptance of PRISMA. As shown in Fig. 1(b), good agreement is obtained with predictions from GRAZING (histograms) for channels involving few nucleon transfer. This can be interpreted as a dominant successive transfer mode over pair transfer or other transfer mechanisms. On the other hand, larger discrepancies are found in more exotic channels, which could be an indication of the presence, in these cases, of other reaction mechanisms not included in the model.

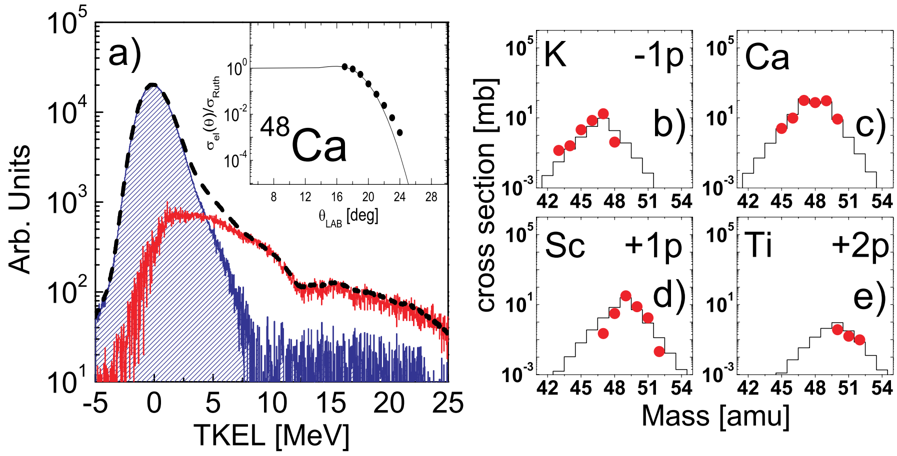

Fig. 1. Panel (a): the TKEL distribution of ^{48}Ca (angle-integrated) measured in PRISMA without coincidence with γ-rays (dashed line) and requiring a γ-coincidence in the Ge array (solid line). The difference spectrum (shaded area) gives the pure elastic scattering contribution. The points in the inset give the ratio of the elastic peak to the Rutherford cross-section over the angular acceptance of PRISMA, compared to the calculation by the GRAZING code [2]. Panels (b)–(e): experimental total cross-sections for some of the most intense transfer channels (symbols), compared to predictions by GRAZING (histograms).

Fig. 2 shows examples of γ-spectra measured by the CLARA array in coincidence with ^{49}Sc and ^{49}Ca ions detected in PRISMA. Apart from the strong peaks already observed in deep-inelastic heavy-ion reactions in thick target experiments at lower energies, *i.e.* around the Coulomb barrier [5], additional transitions are visible, previously observed in transfer reactions with light ions only [6]. A similar pattern is found in other systems (^{47}Ca and ^{50}Ca). This is mostly caused by the very short lifetimes of the corresponding states which leads to in-flight emission of deexciting transitions.

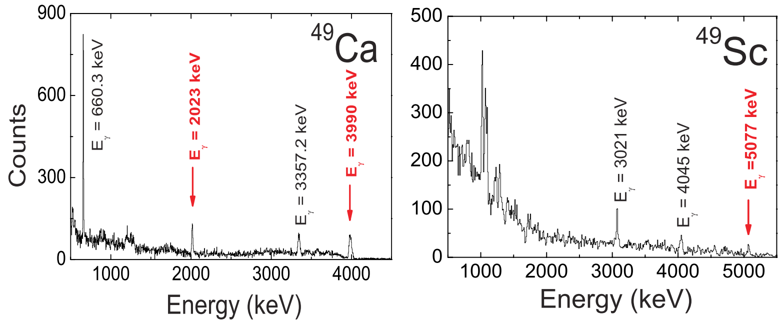

Fig. 2. Gamma spectra of ^{49}Ca (left) and ^{49}Sc (right). The arrows indicate the transitions which have been observed in reaction involving light ions only [6].

3. Conclusions

Preliminary results from the experiment ^{48}Ca + ^{64}Ni at 6 MeV/A, performed with the CLARA-PRISMA setup, have been presented. They include cross-sections for the most intense transfer channels measured relatively to the elastic scattering of ^{48}Ca. A semiclassical model well reproduces the data corresponding to $(-1p)$ and $(+1p)$ channels, while more massive transfer channels, presently under analysis, may involve additional contribution from pair transfer and evaporation modes. The γ-spectra display as sharp lines also transitions from short-lived states, in contrary to thick target experiments.

The work has been supported by the EU (Contract EURONS Nr. RII3-CT-2004-506065) and by the Polish Ministry of Science and Higher Education (Grant No. 1 P03B 030 030 and N N202 309135).

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